& Lec (17) 30

optical receiver:

- transform optical signal into electrical signal
- Main Component ⟹ Photo detector (PD)

1)- high responsivity (Quantum efficiency $R = \frac{\eta \times \lambda}{1.24}$)

2)- Cut off wavelength = $\lambda_g = \frac{1.24}{E_g}$

3)- Fast Response

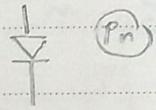
4)- low Noise power (dark current $\frac{S}{I}$)

5)- Small area

6)- Temperature insensitive

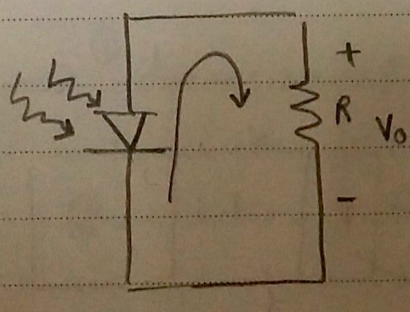
7)- low cost, avaliable, large life

* Common PD (photo diod):



mode of operation PD

Photovoltaic



Low Responsivity

Low Area Capture

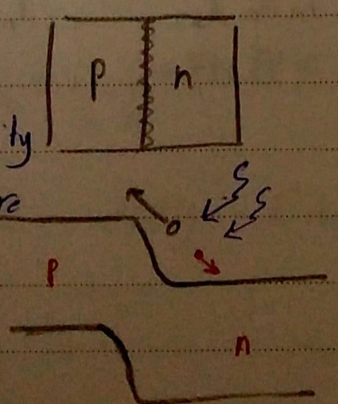
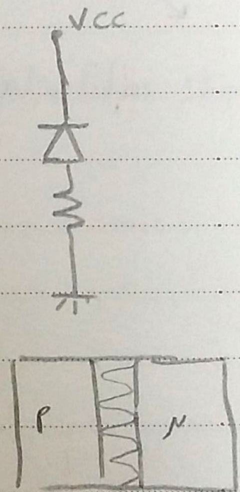


Photo Conductive

R.B

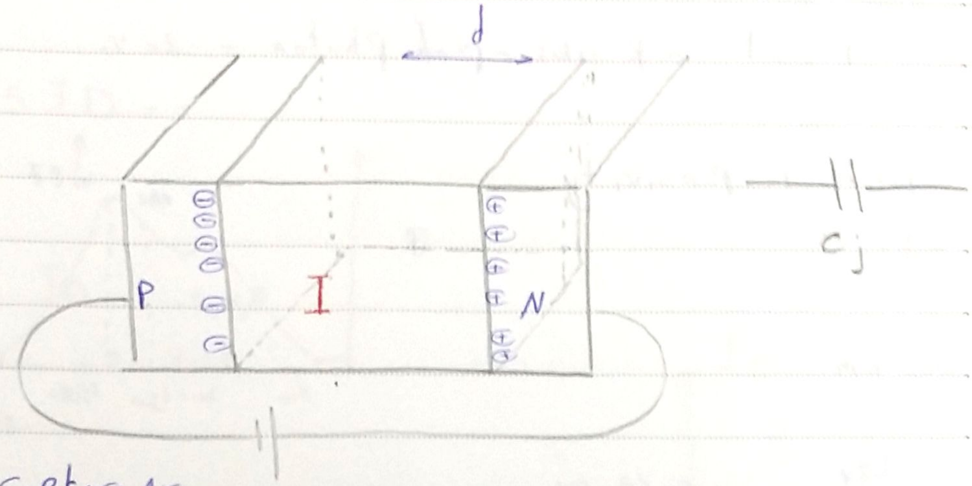


high responsivity

large capture are

-Nois → reverse leakage current

P I N (Positive intrinsic Negative):



1). large Capture Area

2) - fast response

Rise time

$\tau = RC_j =$ time Constant

$\tau \downarrow \Rightarrow$ discharge rapidly

area of plate

$C = \frac{\epsilon A}{d} \downarrow$

spacing between plate

ex $v = v_0 \, e^{-t/Rc}$.

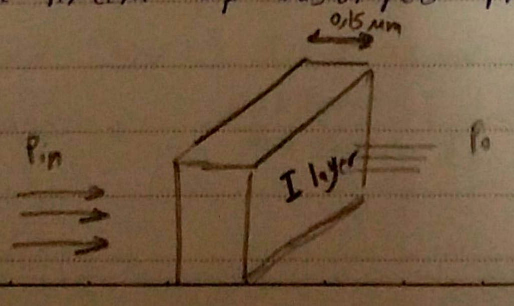
Ex: (20 Marks in final)

Given PIN made $In_{0.53}\, Ga_{0.47}\, As$

a) - if the thickness of the I layer = 0,15 μm

& absorption Cofficient α = 1,5 μm^{-1} at λ = 1300 nm.

Determine the Percent of obsorped Photons by P I N Diode ??



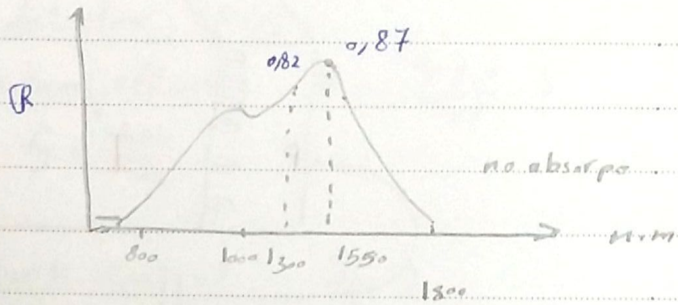
/ /

$$P_o = P_{in}\, e^{-\alpha L} = P_i\, e^{-1,5 \cdot 0,15} \Rightarrow P_o = 0,8\, P_{in}$$

$\Rightarrow$ Percent of absorped photon = 20 %

b)- given responsivity

$E_g = ??$



$\lambda_g = 1800$ nm

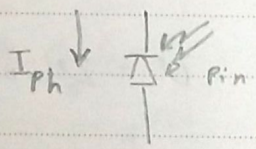
$\Rightarrow$

$$E_g = \frac{1,24}{1,8\ (\mu m)} = 0,69 \text{ eV}$$

c) Determine $P_{inc} = ??$ for generating $I_{ph} = 10\text{nA}$ at $\lambda = 1,55\ \mu m$

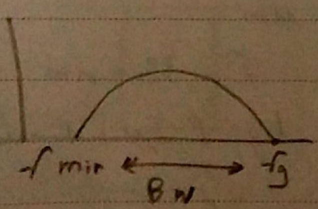
$$\mathcal{R}\Big|_{\lambda = 1,55} = \frac{I_{ph}}{P_{inc}} \Rightarrow 0,87 = 10 \times 10^{-9} / P_{inc}$$

$\Rightarrow P_{inc} = 11,5$ nW

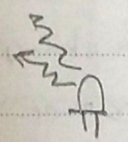


* η & $\mathcal{R} \Leftrightarrow f(\lambda)$

d) Will ~~have~~ the PIN detector detect the maximum emitted λ from LD made from GaAs ??

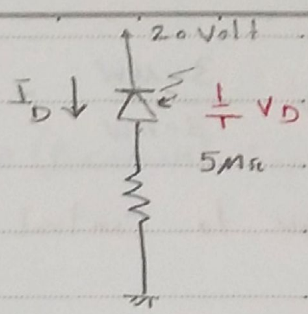


$$\lambda_g = \frac{1,24}{1,424} = 860 \text{ nm}$$



E).

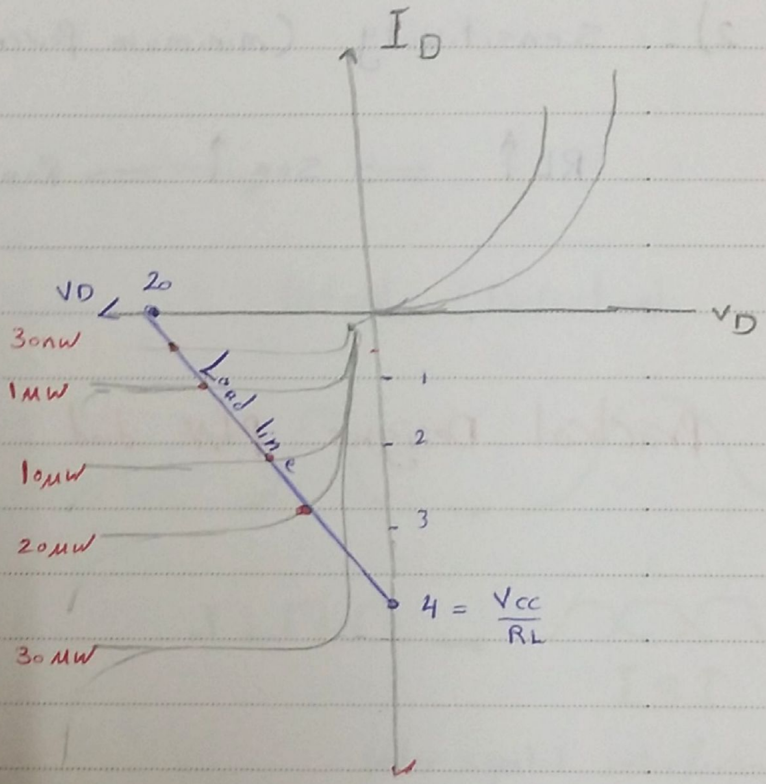
Draw the load line ?



$20 + V_D + 5\, I_D = 0$

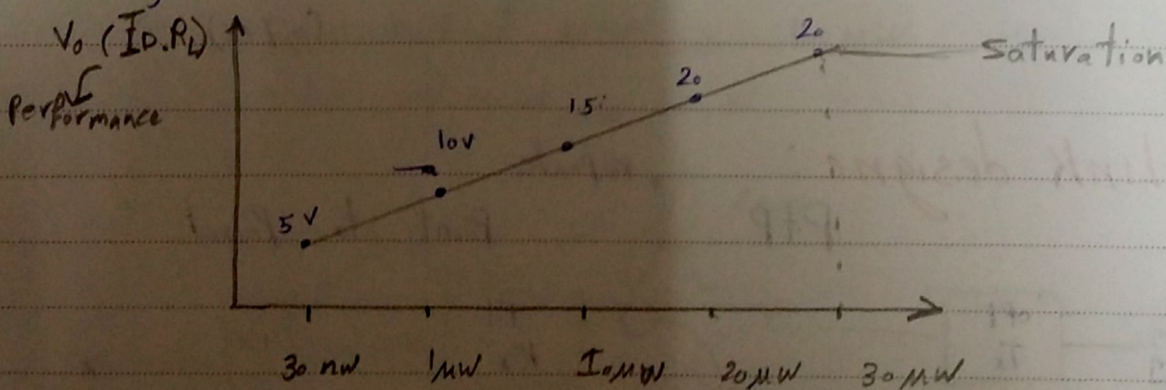
$V_D = 0 \implies I_D = -4\,\mu A$

$I_D = 0 \longrightarrow V_D = -20$ Volt



F) what is the Dynamic range

range of incident optical Power in wich Performance in linear



$$\text{Dynamic range} = \frac{\text{max Power}}{\text{min Power}}\Big|_{dB}$$

D.R $\Rightarrow \dfrac{30\,\mu W}{30\,nW} = 10^3 \Rightarrow 10 \log(1000)|_{dB} = 30\,dB$

how to control on the Dynamic range:

1).

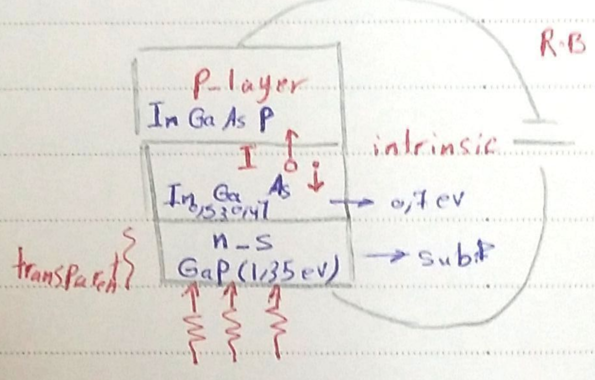
With increas $R_L \Longrightarrow$ Rang $\downarrow$

With decreas $RL \Longrightarrow$ Rang $\uparrow$

2). sensitivity (minimum power recived) = 30 nW

$RL \uparrow \Longrightarrow$ Sen $\uparrow \Longrightarrow$ Rang $\downarrow$

Practical Designe PIN diod:



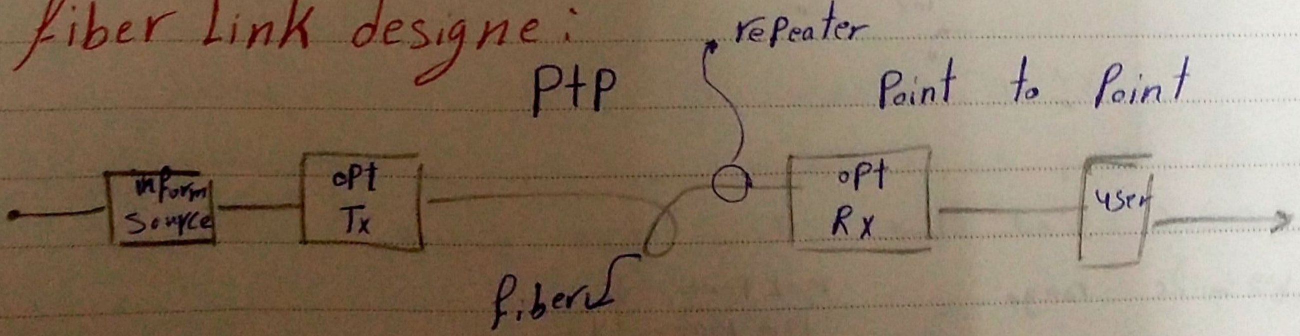
$\lambda = 1,5\,\mu m$

$f = 193,1$ THz

(0,7 ev)

fiber Link designe:

PtP Point to Point



/ /

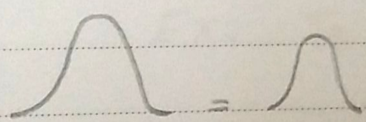
splice (Permenant Connection)

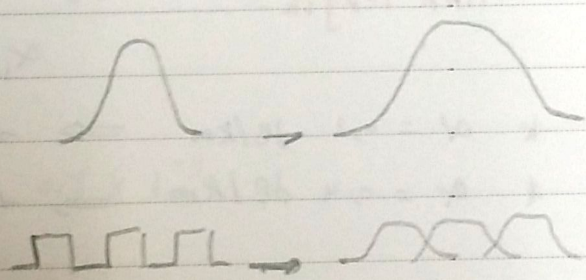
Connector : 1) Connect fiber To Tx , Rx blocks
2) testing & measuring

fiber link :

Attenuation

Bitrate (Dispertion)





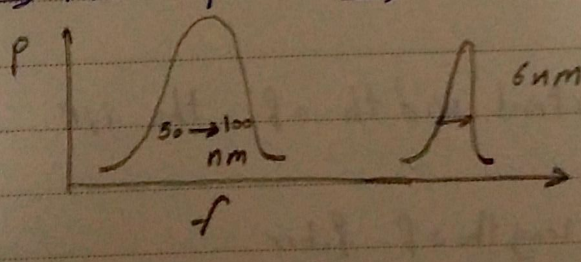
IsI

inter symbol interferance

Power Budget link :

LED → hunderd of μW → $100 \mu W$

LD → tens of mW → $1 mW$



Source has Power , Spectral width

Att Disp

Sensitivity
(attenuation)

dB dBm

$$10 \log 10^{-3} = -30\, dB$$

$P_r = 1mW$

$$10 \log \left(\frac{10^{-3}}{10^{-3}}\right) = 0\, dB$$

Ex:

$P_t = -8$ dB

$P_r = -34$ dB

5 splice each has loss 0,1 dB/km

2 connector " " " 0,75 dB/km

safety margin

$$\text{link length} = \frac{(-8 - -34) - 5 \times 0{,}1 - 2 \times 0{,}75 - (3dB)}{\alpha_{loss} = 0{,}2} \cong 52{,}5\ km$$

* $\alpha = 0{,}2$ dB/km $\Rightarrow \lambda = 1550$ nm
* $\alpha = 0{,}4$ dB/km $\Rightarrow \lambda = 1300$ nm

2) Dispersion

1)* operate on single Mode fiber

$\Rightarrow$ modal despersion = Zero

2)* material dispersion

Ex : $D_{mat} = 5$ Ps / km.m

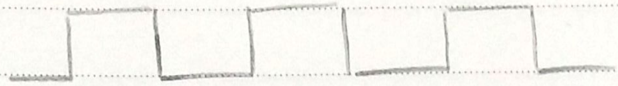
spectral width of the i/p

$\tau_{dispersion} = \sigma_\lambda \times D \times L$

length of fiber

optical Source (LD) $\rightarrow$ 0,1nm $= \sigma$

$\Rightarrow \tau_{dis} = 5 \times 0{,}1\,n \times 1\,km = 0{,}5$ Ps



$\xleftrightarrow{T_b}$

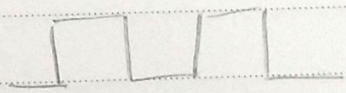
$BW = \frac{1}{T_B}$

$\tau \leq 0{,}7\, T_b$

τ must be $\leq 0{,}7\, T_b$

Ex:

$T_B = 1\,\mu\,sec$



$T_b = \mu sec$ len

$$\text{length} = \underbrace{5\times10^{-12}}_{\text{fiber (D)}} \times \underbrace{0{,}1\,nm}_{\text{source }(\sigma)} \times \underbrace{L}_{1\,km} < 0{,}7\times10^{-6}$$

Ex: $T_B = 1\,n\,sec$

$$\text{length} = 5 \times 0{,}1 \times L < 0{,}7\times10^{-9}$$

$$t_{syst} = \left(\tau_{disp}^2 + \underbrace{t_x^2 + t_r^2}_{\text{Time Processing delay}}\right)^{\frac{1}{2}} < 0{,}7\ \tau_b$$